Management Report No 1

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SCIENTIFIC PROBLEM DEFINITION

GREAT SMOKY MOUNTAINS NATIONAL PARK

1975 - 1976

NATIONAL PARK SERVICE

SOUTHEAST REGIONAL

UPLANDS FIELD RESEARCH LABORATORY

GREAT SMOKY MOUNTAINS

NATIONAL PARK

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Department of the Interior

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Introduction

The purpose of the following report is to review the major resource
management problems of the Great Smoky Mountains National Park, to
discuss the scientific work already completed in the Park which relates
to these problems, and to define present research needs for resources
management. The report is intended for use by park administration
and scientists interested in doing contract work for the Park Service.

Present research needs are divided into three priority groups, based
on the management problem they concern and the amount of information
already available on the problem.

First priority problems are those which involve a major loss of park
resources. In general, first priority problems involve large areas
of the park, are chronic, and need immediate attention. The information
currently available is not adequate for making sensible management decisions.

Second priority problems are those of unknown severity concerning rela-
tively small areas of the park (with the exception of problems which
involve an irreplaceable loss, i.e., species extinction); those which
already have an active and partially successful management program, which
may require modification or become inadequate if the problem expands in
the future; and those areas of basic resource inventory where present
data are inadequate for future needs.

Third priority problems concern additional research in areas where the
present research program is felt to be adequate with respect to the
management needs of the park. Research on these problems may not be
directly related to resource management but concerns some feature of the
park and may provide data which can be used in the future.

Projects or problems may sometimes be interdependent, and the priority
of one problem may depend on that of another.

I. The European Wild Boar - population expansion and rooting damage.

A. The problem.

The European Wild Boar is an exotic species accidently
introduced into the National Park. The species is altering
native vegetation and may be having an adverse impact on some
native animal species. The vegetation damage is extensive,
and about 3/4 of the total area of the park is presently with-
in the hogs' range. (For a more detailed definition of the
problem, see the management report by Bratton, 1974).

B. The status of the present management effort.

The number of wild hogs in the park and the surrounding areas
has increased substantially in recent years, resulting in the
invasion of the new areas and increased damage due to rooting.
In the past two years, the hogs have invaded the lower elevations
in the Greenbrier section of the park.

C. The status of the research effort.

The general biology of the wild boar is already well discussed
in the literature. European work has determined the basics of
morphology, ecology, behavior, and management as a game species.
American work by Tennessee Game and Fish Commission and by
students from the University of Tennessee has determined the
morphology and general biology of the local populations. The
Research Biologist in G.S.M.N.P. has conducted a literature
search, and copies of important references are available at the
Field Research Laboratory or the park library.

Very little is known about population ecology, behavior or food
habitat preferences in the Southern Appalachians.

D. Research needs.

Research on the European Wild Boar in the Great Smoky Mountains
needs to be concentrated in two areas. The first of these is

the collection of information which may be used directly by
the control effort. This includes research on hog population
dynamics, on methods of estimating the hog population, on
possible improvements on control techniques, and on hog behavior.

The second area is the collection of information on the impact
of the hogs on native species and other park resources.
Information is needed about extent of rooting damage, food
habits, competition with other species, effects on soil
structure, erosion and effects on water quality. Long-term
studies on the recovery of damaged areas are also needed.

RESEARCH PROBLEMS CONCERNING THE WILD BOAR (These may be approached individually or in related groups.)

I. The most important single problem is finding a method of estimating the hog population from season to season and year to year. Although the hogs have been in the park for over 25 years and have been a management problem for most of that time, no effort has been made to keep running estimates of population increases or range expansions. Present guesses of the total hog population vary from 500 to over 3,000 individuals. Obviously to determine the success of the control effort, the number of hogs must be determined accurately. The personnel managing the control effort need to know the population fluctuations and relative densities of hogs in different areas of the park.

The study of the hog population should not only emphasize obtaining a population estimate for the years during which the study is conducted, but should extract a method which can be used by the Park Service to predict long-term changes in the hog population.

A. Limitations on the study.

1. The study needs to be completed within 2 to 3 years of the onset of the new control program.

2. Because of poaching activity and the control program, the hog population is disturbed by human activity. This may make field observation of marked animals or mark and recapture type techniques more difficult to use or subject to increased error.

3. Simple counting methods are unlikely to be effective because of the hog's complex behavioral patterns and seasonal movements.

4. The study requires an experienced primary researcher with previous field work in the area of large mammal population dynamics.

5. All effects of the study on the resources of the park must be discussed in the proposal. Any shooting, trapping, use of chemicals (including paints, dyes or hog attractants) must be outlined in detail.

B. Scientific aspects.

1. Hogs are difficult animals to work with in many respects and several idiosyncrasies of their behavior should be considered in the course of developing a long-term population estimating technique. Several of the following points will influence the accuracy of the method of population estimates:

   a. Seasonal differences in hog movement, food and habitat preferences, and annual differences in reproductive success.

   b. Hogs form herds, the structure of which may depend on the season and on the age and sex of the animals.

   c. The amount of hog sign is directly related to the characteristics of the habitat. This is especially true of rooting intensity.

   d. Hogs are nocturnal, particularly when harassed by predators and hunters.

   e. The vegetation of the Carolina side of the park is quite different from that on the Tennessee side, and the vegetation around Cade's Cove is different from that around Greenbrier. Therefore, a study of each section of the park or each habitat type is required unless scientific justification to the contrary is provided.

2. When such a study is done, variances of the different estimates should be analyzed and used as a criterion for technique selection.

3. Choice of a technique may be based on a cost/benefit ratio which weighs accuracy against the number of man hours and the total expense of each possibility.

4. Applicable remote sensing techniques should be evaluated to determine accuracy and cost/benefit ratios.

C. Recommendations for funding.

1. If a suitable outside contractor can be found, a population study should be considered for funding during the coming year.

II. Constructing a data base and a model for predicting hog population fluctuations: After estimates are available for the hog population, the next step is to construct a predictive (statistical) model, using measured data on annual differences in reproduction, age structure of the population, environmental variables influencing reproduction and measured mortality rates. The model output should include estimates of hog population densities and fluctuations which can be used to determine the number of hogs which should be removed in a given year to stabilize or reduce the population to a desired level.

A. Limitations on the study.

1. Population and environmental variables need to be defined and data collection techniques evaluated.

2. Field work needs to be executed. There are a number of European papers already available as well as some data on hog reproduction in the Southern Appalachians which may provide a rough data base for variable definition.

3. Phenological and environmental variables important to hog reproduction are not adequately quantified for model construction at present.

4. The model should be presented in a form usable by park management staff.

5. The accuracy of the model must be clearly defined for both the original data matrix and the long/short-term prediction.

B. Scientific aspects of the study.

1. The model should be able to predict with an established error range:

a. Population fluctuations related to mast level and environmental conditions.

b. The best age classes of females to remove and their relative reproductive value.

c. The impact of different intensities of control on the population.

d. Long-term effects of continuing the control program at a specific level of intensity.

C. Funding recommendations.

This study should be conducted concurrently with the population study.

III. Design of better hog traps: The old trap designs limit the capture to single animals or small family groups.

A. Limitations on the study.

1. There are dollar limitations on the number and kind of methods that may be tested.

2. Trapping techniques should affect other species as little as possible.

3. The study should evaluate old methods and develop new methods.

B. Scientific aspects.

1. Information available in the literature should be used.

2. Careful record keeping is necessary to evaluate different designs properly.

C. Funding recommendations.

Park Service staff are probably the best personnel to use for this work since it needs to be done over a long period of time and involves the use of special hardware. Interested outside researchers are encouraged to contribute. An independent study might be considered if someone were interested and the work could be done in close conjunction with the Park Service program.

IV. Development of selective baits. The baits presently used tend to attract a wide variety of other mammals. The most commonly bait is cracked corn.

A. Limitations on the study.

1-3. Same as in Problem III.

4. Penned animals may be needed for some of this work.

B. Scientific aspects.

    1. Modern ideas on the subjects of olfaction and animal communication may be helpful.

    2. A comparison of food location by hogs with the behavior of other mammals may provide useful information about interspecific competition.

    3. If one knew what hogs were cueing to when they located food underground, one might be able to develop a "best" bait.

C. Funding recommendations.

    Work in this area should be coordinated with resources management staff and could be done by Park Service staff in conjunction with the control program.

V. Hog behavior. More information on the general patterns of herd structure would be useful. Detailed behavioral information can sometimes be used to predict what the hogs will do in a given situation.

A. Funding recommendations.

    Work in this area should be funded concurrently with the population study.

VI. Hog damage to native plant communities. This is one of the better known areas of the "hog problem" with several papers already completed and more information being gathered. The most information is available for Gray Beech and Northern Hardwood Forests. There is presently an intensive study underway on the vegetation of the Grassy Balds which will contain some information on hog rooting. One paper on winter rooting activity (Howe and Bratton) covers some of the patterns of disturbance in low elevation successional forests. Most of the work has covered the impact on the understory and not on the canopy. The recovery times for most of the heavily damaged areas are not known. This requires more than one study and some of the work should be long.

A. Limitations on the study.

    1. Almost no work has been done on the Carolina side of the park in this area.

    2. The problem needs to be divided into natural problem groups.

3. Without basic resource inventory data on vegetation and soils, estimating the total amount of damage for any section of the park will be difficult if not impossible.

B. Scientific aspects.

1. Vegetation recovery is one possible project, and will require exclosures. Recovery after rooting in an area with a closed canopy which has been attacked annually is probably rather slow. One criterion for measuring the success of a hog control would be vegetation recovery after a quantified reduction of the hog population.

2. Impact on trees, particularly in the area of seedling reproduction, should be assessed. This may have to be done by park staff on a long-term basis. Impact of hogs on mature trees can probably be done using standard techniques for measuring growth. Additional studies may involve developing methods for assessing root system damage.

3. Impact on individual species is included in the rare and endangered plant species program. However, in this type of study special plots might be established for the genus Lilium and others that are prime food items.

C. Funding recommendations.

1. Considering results to date, only moderate funding is in order.

2. If funds are not available and priorities are determined appropriately, the park staff can continue current work in this area.

3. The raw data matrices and sampling techniques, including site locations, must be made available to the Park Service for future studies.

4. The impact of hog damage per unit area of the park will have to be addressed and related to basic resource inventory. This may best be directly coordinated by Park Service staff.

VII. Food habits. More detail is needed, viz., a specific list of preferred food plants and animals. Such a list would be useful to both the control effort and an impact assessment. Animals will be made available for study. One study on food habits in the park has been completed.

A. Limitations on the study.

Material may not be available from the full spectrum of hog-utilized habitat types, unless special provisions are made for obtaining it.

B. Scientific aspects.

Material should be identified as precisely as possible.

VIII. Effects of hog damage on aquatic systems, soil erosion, and stream siltation. Hog rooting has increased and continues to increase the silt load in some of the streams in the park and the removal of the surface soil from certain types of forests. The magnitude of the problem is not known.

A. Limitations on the study.

1. Lack of basic resource inventory data will inhibit making damage estimates on an all-park scale.

2. Soil erosion might be approached as a separate topic.

3. Lack of baseline data on stream quality may inhibit some of this work.

4. In some cases, factors involved in assessing silt loading due to hogs and hikers may be difficult to separate.

B. Scientific aspects.

The study should be coordinated with other work in progress on stream quality.

C. Funding recommendations.

1. This work is at least as important as terrestrial impact and the health and safety of hikers may be involved.

2. Funding for this work will be considered for this year.

IX. Associated topics. A number of other problems concerning hogs deserve attention. One is parasites and disease agents that may be associated with the animals. Although funding limitations will probably prevent the direct support of additional problems this year, material from collected animals can be made available to researchers interested in problems concerning parasites and morphology. If the state and Federal permits are obtained, live animals may be made available to people interested in using penned animals for behavioral or physiological studies.

FIRST PRIORITY PROBLEMS

II. The Native Brook Trout - decline of the population.

   A. The problem.

       Over the past thirty years the U.S. Fish and Wildlife Service
       has censused the fish populations in the park. The native
       brook trout has declined in numbers during this period, and
       its range has been restricted to high elevation streams and
       small secondary creeks. The reason for this decline is uncertain,
       but it is probably the result of combined factors, including the
       introduction of the rainbow and brown trout into the area,
       overfishing, and changes in the character of the streams in the
       park. If the native trout population continues to decline at the
       present rate, brook trout of the southern Appalachian strain
       may disappear from the park entirely, leaving only non-native
       species in streams. For details on the problem, contact
       Ron Jones of U.S. Fish and Wildlife at GSMNP.

   B. The status of the present management effort.

       The fish populations are among the most intensively managed
       resources in the park. Stocking of non-native trout was
       practiced in the past and the hatchery stock of brook trout
       from a New England strain has been introduced into park streams.
       Harvesting of fish has been allowed since the founding of the
       park, and was of course practiced by the early residents of the
       area. Stocking of non-native trout has ceased, and fishing
       regulations were recently modified in an effort to reverse the
       present trend in the trout populations.

   C. The status of the research effort.

       The Fish and Wildlife Service has accumulated a large data matrix
       on the fish populations in the park. The data include the species,
       physical parameters of the stream, and fish sizes. Most of this
       data has not been analyzed.

       One project on the restocking of native trout in a stream which
       has been free of all trout species for a number of years is
       presently under way; however, results are not yet available.

A considerable body of literature exists on the biology of trout, and much work has recently been devoted to modeling fish populations. The literature has not been searched in relation to the trout problem in the park.

A group from Tennessee Technological University is presently conducting work on the physical parameters of streams in the park, and the relationship between brook and rainbow trout populations.

D. Research needs.

1. The status of the native trout as a subspecies separate from the New England strain needs to be ascertained.

2. The source of the native trout's present problems needs to be identified.

3. The potential remedies needed to alleviate the sources of the problems need to be considered.

RESEARCH PROBLEMS CONCERNING NATIVE BROOK TROUT IN GSMNP

A. Is the native Southern Appalachian trout a separate subspecies? How genetically different from other brook trout populations is the native trout? Has there been any mixing between hatchery and native trout in the park?

Some work in this area, basic protein chemistry, is presently being pursued and may be found to be effective for specific determinations.

1. Limitations on the study.

a. Defining subspecies and species is a relatively difficult matter. Different areas would have to be investigated and the sample would need to be well defined.

b. Newly developed techniques would probably be required for this work (i.e., protein chemistry, chromosome mapping, etc.).

c. Electrophoresis is presently being applied in an attempt to solve this problem.

2. Funding recommendations.

    Await outcome of present investigations.

B. The effect of physical factors and of non-native species on the distribution of brook trout in the park..

    1. Funding recommendations.

        Further funding in this area should await the outcome of work presently underway by contract with Eric Morgan, Tennessee Technological University.

C. Analysis of species composition and size data from various streams in the park.

    1. Scientific aspects.

        Some basic studies which might be done:

        a. What is the relative productivity of fish in the different streams in the park?

        b. What are the differences in species composition from stream to stream?

        c. What are the differences from species to species in terms of range in the park and type of streams inhabited?

        d. Are there any relationships between species composition and forest type? Are there any differences in species composition between logged and unlogged stands?

        e. What is the structure of the brook trout population in the park? The other trout populations?

        f. What is the probable impact of fishing on the trout populations?

        g. Could the fishing regulations be modified to improve fish production?

        h. What is the effect of removing all legal fishing of brook trout?

i.   The existing data matrix may be adequate for constructing
      population models if a literature search could determine
      size at maturity and reproductive potential of different
      sizes of fish.

2.   Funding recommendations.

     a.   The large amount of information resulting from the
           Fish and Wildlife Service Fisheries Program could be
           very useful for making sound management decisions if
           it were available in an analyzed form. Assistance
           is needed before these analyses can be completed.

     b.   This work is recommended for funding within the next
           two years.

3.   Habitat manipulation to favor viable native brook trout
     populations.

     a.   Basic studies of interest include:

           (1)   The effect of competition between native and
                 stocked fish populations?

           (2)   The effect of removal of stocked species?

           (3)   The impact of various fishing regulations on trout
                 populations.

     Special requirements:

           (1)   Special regulations.

           (2)   Close coordination with resources management staff
                 of the park.

     b.   Funding recommendation.

           Contract funding would need to parallel development
           of NPS staff capabilities to assess and assist with
           active manipulative programs.

III. The balsam woolly aphid - population expansion and damage to Fraser fir.

    A. The problem.

        The balsam woolly aphid is an exotic species which has been introduced into the national park. The aphid is attacking the endemic Fraser fir population and is modifying the structure of the spruce fir forest in the park. The aphid has been in the northeast section of the park for a number of years, but recent range extensions have moved it to the Indian Gap area. The aphid is also a threat to the most extensive stands of virgin red spruce forest in the east and the largest remaining area of Fraser fir forest.

    B. The status of the present management effort.

        In the past, park management removed all aphid-killed trees in an effort to control the spread of the aphid. Despite this activity, its range has increased. No effort has been made to spray or to kill the aphid in selected stands.

        The Forest Service has done research on the control of the species. Biological control has not been effective, but heavy application of insecticide may preserve small stands of fir.

    C. The status of the research effort.

        Little work has been done on the balsam woolly aphid problem in the national park. A thesis on the effect of aphid damage and its relation to forest succession is presently being prepared by Rex Boner at the University of Tennessee. The park does not have a complete collection of the literature on the species.

    D. Research needs.

        The Service needs to know where the aphid is, how fast it is spreading, how it can be controlled, and what its ultimate impact is likely to be. The first priority of this research program is the preparation of a complete literature review and a concurrent assessment of the magnitude of the problem. The first study initiated by the Park Service should define the problem clearly in terms of the effects within the park and review what work has already been done on the species and its near relatives.

A. The most important single problem is to prepare a general management report including a literature review and the range of the species in the park. The direction of further research should depend on the results of this preliminary report.

   1. Limitations on the study.

      The study needs to be completed quickly so that further research and/or management actions can be initiated.

   2. Scientific aspects of the study.

      a. The study report should review European work and the work of other agencies, i.e., the Forest Service and the Canadian Forestry Department and determine the status of their programs.

      b. The report should outline the present distribution of the aphid in the park, rate areas according to the intensity of infestation, and evaluate damage.

      c. The report should include as much material on the population dynamics of the species as possible.

      d. The report should contain recommendations for future research and management methods that might be tested.

      e. Aerial photography should be evaluated as a tool for locating infestations of the aphid in the park.

      f. Permanent plots should be established for evaluating aphid range extensions and intensity of damage.

      g. The approach should include the differences, if any, which can be noted between aphid range extension in disturbed and undisturbed forests and forest types.

   3. Funding recommendations.

      Ideally the Park Service scientific staff should be able to take care of this sort of preliminary work and management report. However, because of present staff shortages, it is unlikely that National Park Service staff will have time for this project. Staffing limitations lead to the recommendation that funding be provided for contract at a moderate level.

I. Basic Resource Inventory - data collection and storage

A. The Problem.

   The park has no coordinated system for mapping its various
resources, either in a temporal or a spatial framework. Many
of the units of interest to the manager have never been adequately
defined on an all-park basis.

   The ranges and population densities of most of the species
present in the park are unknown. In some cases the data may
be available, but there is no record in the park.

   No effort has been made to keep track of long-term changes in
different communities within the park. Most of the successional
plant communities have not been studied in detail. Damage after
fire, windfall, wild boar rooting or insect attack has seldom been
measured and quantified. There are no long-term population esti-
mates available for any large mammal species, and the bird popu-
lation work is largely restricted to the Audubon Christmas count.
The U.S. Fish and Wildlife Service conducts the only regular
survey in the park.

   The information presently available is, therefore, unsatis-
factory or unretrievable for making management decisions in most
areas. There is no framework available for estimating animal
populations on a habitat basis. No prediction can be made of
fire behavior at a particular site. If the park wishes to modify
some area (build a road or a camp site), the possible choices
have to be inspected as the decision is being made. Many sites
in the park which deserve special protection status go unnoticed
until a development project has been planned. No baseline data
is available to assess sudden changes in park ecosystems. The
status of many species native to the park is poorly known.

B. The status of the present management effort.

   This is an information problem which relates to management.
Some uncentralized records are kept by the park. A vegetation
map was prepared in the late 1930's. The SCS has mapped the
park, but the maps are old, and few areas outside of the coves
were surveyed in detail.

C. The status of the present research effort.

    Most of the resource inventory work in this region is being done outside the park. TVA is currently preparing a set of resource inventory maps for the Tennessee Valley which include the entire park. The technology already exists to accumulate and store large amounts of data for computer mapping. Work of this sort has been pursued by a master planning team for the park, and is being done in other parks. Glacier National Park now has a project for computer storage of vegetation and fuel data.

D. Research needs.

    The amount of work that needs to be done in the inventory area is massive. Detailed vegetation maps are not available to the park.

    Research needs here can be divided into the following categories:

    1. Terrestrial geographical information.

    2. Aquatic geographical information.

    3. Terrestrial temporal information.

    4. Aquatic temporal information.

    5. Physical factors.

    A standard format for the storage of geographic information must be developed. The system must be available to the park, and should be run by staff within the park. The system should be flexible, allowing for storage of multivariate data sets which can be used to associate multiple data matrices to an identified map position. Such a system could be borrowed from another agency and modified for use in the park. Previous work by the National Park Service and TVA has already divided the park into cells. The establishment of a working information storage and retrieval system with the ability to make usable maps from stored data sets is required.

    After a general matrix for data storage is developed, the park should supply the information needed in some of the more critical and basic areas: a basic vegetation map, rare and endangered species, etc. This work should include information on fuel types and soils.

Once the system is running, independent researchers should
be encouraged to use the system and add to the information matrix
already available to the park.

Temporal changes are difficult to work with and require long-
term programs which are best organized from within the park.
Important areas where work should be initiated in the near
future include an all park survey for fluctuations in large
mammal populations, permanent plots in successional areas, and
monitoring of all endangered species.

Mast crop, fruiting, and flowering times, and intensities
are important to both management and park visitors interested
in floral displays. As soon as a data storage format has been
organized, an effort should be made to quantify mast production
on an annual basis, and to keep tract of phenological events for
different species.

This next section is not intended to be a discussion of all
of the problems that need to be addressed by a resource inventory
effort, but to provide some examples of the types of studies that
need to be done and what kind of data should be acquired.

E. Vegetation map.

1. Limitations on the study.

This is a very large project which will take a strong
central organization trying to map the entire park, several
years to complete.

2. Scientific aspects.

a. The object is to create a system of classifying areas
according to their past history and present species com-
position in such a way that the information can be used
directly for a number of management problems.

b. The management areas which take priority are fire
history, successional history, human history, wildlife
utilization, erodibility and susceptability to damage by
visitor use.

c. The classification system used should be hierarchically
organized so that accurate maps can be produced on at least
two scales; the scale of the topographic maps and a scale
which displays the whole park.

d. A management interpretation should be included for each unit with the basic species composition.

e. All maps produced should be on a scale that permits accurate overlays on 7 1/2 minute quads.

f. Fuel and soil types should be mapped in conjunction with the vegetation map.

g. Versatility is of primary importance.

3. Recommendations for funding.

a. The initial work should cover only a small segment of the park. This would allow feedback to management before a large amount of money is spent, and would provide time for establishing the best system.

b. This work requires expensive aerial photography and crews for ground truthing.

c. Any proposal which touches in the area will need to be closely coordinated with park staff to develop a suitable classification "system."

d. Pilot funding is recommended within the next 2 years.

e. Some work, particularly accumulating photography and initial establishment of mapping units, will of necessity be done by Park Service staff.

F. Aquatic systems classification.

1. Limitations on the study.

a. This is a very large problem and will require a strong central organization. It is anticipated that it will take several years to complete.

b. Data organization and storage should be interactive with the system established for terrestrial systems.

2. Scientific aspects.

a. The park needs baseline data on stream quality.

b. The park needs to know what factors influence the fish populations in the streams and how these vary from stream to stream.

c. Some standard classification needs to be developed for the streams in the park.

d. The stream floras and faunas need to be described and classified.

e. When future management problems arise, the park needs to know stream conditions before disturbance to assess observed changes.

3. Recommendations for funding.

This work will require major funding.

G. Mast survey.

1. Limitations on the study.

a. Accurate estimation of available mast will require quantifying the amount of each forest type at different elevations. The problem is, therefore, related to vegetation mapping.

b. The studies need to be conducted on a seasonal basis, at minimum; therefore, after the sampling scheme is established, intensive involvement will still be required to accomplish the needed field work.

2. Scientific aspects.

a. Fruit crops aside from oak mast must be considered. These include grapes, walnuts, hickories, blueberries, apples, pine seeds, beech nuts, etc.

b. Fruit crop availability needs to be related to climatic data and the general phenology of the forests in the park.

c. Elevation differences need to be documented.

d. The effort should be coordinated with surveys from nearby areas, both state and Federal.

3. Recommendations for funding.

    a. A vegetation map is required before data from this sort of survey can be interpreted. It should, therefore, be carefully integrated with other areas of resource inventory.

    b. Although the establishment of the first survey might be done by a contracted party, the Park Service will eventually have to be involved with and augment the manpower for this work.

    c. It is possible that data taken by other agencies in nearby areas might correlate strongly to the situation in the park. This should be considered before funding any major work in this area.

H. Estimates of animal populations and ranges.

    1. Limitations on the study.

        a. Species may have to be surveyed individually or in related groups.

        b. Any long-term data collection efforts will have to involve Park Service staff, or be directed by them.

    2. Scientific aspects.

        a. Perhaps the first species that should be considered for this type of work are those which are management problems, such as hogs and white-tailed deer. Animals which can overpopulate or suffer sudden population crashes need the closest monitoring. The endemic and endangered species require attention. The park should have detailed range maps and data about the population dynamics of all species endemic to the park. Survival levels need to be established for rare species so that management action could be taken before the species is extirpated.

        b. The only species for which an analyzed population estimate based on field data is available is the black bear.

c. An attempt should be made to relate population fluctuations of large animals to environmental factors. This would permit a manager to predict species response before the change in the population actually occurs.

d. It is impossible to census all the species in the park, hence the choices should carefully be made and long-term studies initiated.

e. Range maps and habitat preferences should be constructed for as many species as possible.

3. Funding aspects.

a. This problem will require several studies.

b. Eventually, the Park Service will have to become actively involved.

c. Care should be taken not to fragment funding in this area. Population estimates for this and that species for this and that year are not very useful for long-range ecosystem management.

d. Studies which estimate several species at once with the same experimental design would be most acceptable.

SECOND PRIORITY PROBLEMS

II. Rare, endangered, endemic, and extinct species.

A. The problem.

The park is a protected area whose biota includes a number
of rare, endangered, or threatened species. The present
status of many of these species within the park is not well
known. Some are disturbed by hogs and humans. In most
cases, it is not known if the populations are decreasing,
increasing, or stable.

B. The status of present management.

No identified effort is being made to protect any particular
species or sites because of endangered or threatened status,
partially because these sites are not well known. The develop-
ment of a special protection area may change this situation,
but the "problem" species need to be located and their status
assessed.

No reintroductions of extirpated species are presently being
attempted in Great Smoky Mountains.

C. The status of present research.

Increased interest has been shown in endangered species over
the past few years and both the states and the Federal government
have active programs in this area. There is a considerable
body of literature available on some of the vertebrate species
in question, but there is generally little material on plant
species.

The park now has a program to locate endangered plants and
estimate populations within the park. There is not a coordinated
research effort under way, at the moment, on endangered
vertebrates, although several investigators are working on
endemic salamanders.

D. Future research.

The park needs to expand the effort to collect information on
threatened and endangered species listed. This is important
to future planning for the park, as well as to the management
of the individual species. The park manager must know what
species require special protection and where they are located.
The rare and endangered program should be interactive with the
basic resource inventory.

The possibility of reintroducing some of the extripated species can not be considered by park management until a thorough literature search has been conducted and questions about the ecology of the candidates for reintroduction are answered.

RESEARCH PROBLEMS CONCERNING RARE AND ENDANGERED SPECIES.

A. The position of rare and endangered plant species.

This project was begun this summer and will be integrated into basic resource inventory data files. It is being directed by Park Service staff but requires more manpower to check sightings in widely separated areas of the park.

1. Limitations on the study.

   The study is long-term.

2. Scientific aspects of the study.

   The data gathering format is being established.

3. Recommendations for funding.

   a. This work will be continued by Park Service staff.

   b. Students skilled in plant taxonomy and map reading can be used for collecting the data.

   c. Field help for this work might be requested on a volunteer basis (VIP or otherwise).

B. The status of threatened or endangered animal species.

Unlike vascular plants, animals are not usually approached as a group. For this reason, work in this area will probably have to be divided into a number of small projects, or conducted as part of basic resource inventory.

Most of the species on the National list are so rare that it would be difficult to collect much data on time, other than accidental sightings.

The Park Service will direct most of the work and provide the long-term record keeping in the area of endangered species. Presumably some of this belongs in the area of Basic Resource Inventory.

1. Limitations on the study.

    a. These studies are long-term and continuity will be difficult to maintain.

    b. The work will need to be divided among a number of people in several small projects.

2. Scientific aspects.

    These will vary from study to study. Population information is the most important area, followed by habitat preferences, food habits, and possible threats to the populations.

3. Recommendations for funding.

    a. After a program in data storage and basic resource inventory has been established, work on rare animals will be initiated by Park Service staff. Independent investigators are encouraged to work on individual species.

    b. Funding for studies on individual species may be requested if an emergency situation exists, i.e., a species is about to be extirpated.

    c. Some individual species would make good study topics for students who could search literature, map the range of the species in the park, analyze data from reported sightings, etc.

C. The reintroduction of extirpated animal species.

    This is a complex topic which requires close cooperation with park resources management. When a species is considered for reintroduction the following questions need to be answered:

    1. Where is the species likely to become established in the park?

    2. What are its habitat and food requirements?

    3. With recent changes in some of the habitats in the park, is there now an adequate food supply available?

4. Is the species likely to expand its population to the point where it becomes a management problem?

5. How sensitive is the species to human disturbance?

6. Will the species disturb or damage other species?

7. Is the species likely to range outside the park?

8. Could the species cause agricultural damage?

9. How much will it cost in dollars and man-hours to reintroduce a species and manage it after the reintroduction?

10. Is there any possibility that a relict population of the species still exists in the park?

An evaluation of the practicability should proceed and become a part of an environmental analysis concerned with each reintroduction proposal. The beaver may already be reestablishing itself in the park and the otter has expanded its range in Tennessee in recent years. The mountain lion, wolf, and peregrine falcon are all known to have resided on land now belonging to the park, but are believed to be extirpated.

A. Limitations on the studies.

The initial study would probably consist of a prediction of what a species would be likely to do if it was returned to the park. Reintroduction could only follow careful evaluation of the species' potential for success and potential as a problem.

B. Scientific aspects of the study.

1. A literature review is required.

2. The investigator(s) should visit areas where the species is present both naturally and after reintroduction.

3. If reintroduction is attempted, the species should be carefully followed for a period of several years. Protection may be in order for fur bearers and raptors.

C. Funding recommendations.

   1. This is a long standing problem which can be approached
       any time.

   2. The initial reports, before reintroduction, will be
       required.

   3. Funding levels and sources should be chosen when the
       project is completely outlined.

SECOND PRIORITY PROBLEMS

III. Human interference and impact on natural ecosystems.

    A. The problem.

        This is a diverse group of problems of varying severity. The source of the problems is twofold - first, there is a tremendous amount of visitor use in the park, much of it concentrated in very limited areas - and second, many people do not understand how easily natural ecosystems and wildlife can be damaged.

        The first set of problems encompass the matter of hiker impact. This includes trail erosion, trampling of areas around camp sites, fire wood gathering, sanitation, and hiker-wildlife interactions. These problems have worsened in recent years and show no signs of abating. In some cases, the aesthetic qualities of an area are affected, and in others visitor safety is involved.

        The second set of problems encompass the matter of purposeful destruction and/or removal of park resources. This includes the poaching of a number of game species, the poaching of wildflowers, the killing of snakes, illegal "scientific" collecting, and the removal of souvenir items or other "desirable" natural objects.

        The third set of problems encompass visitor-wildlife interactions along the roads and in the campgrounds. Animals are attracted to these areas by garbage and handouts from unenlightened tourists.

        Most incidents concern bears, but other species are sometimes involved.

    B. The status of the present management effort.

        People problems receive more attention than any other group of problems in the park. The only area which would compete in the number of man-hours, etc. would be fire control. Trail crews spend a tremendous amount of time annually on trail maintenance, regular garbage pickup through some sections of the back country, and intensive garbage pickup along park roads. Park personnel spend hours writing up back country use permits and going on trail patrol. Many man-days are spent breaking up bear jams and removing troublesome roadside bears.

        Many of these problems are extremely expensive to combat.

C. The status of the research effort.

Much of the work in the Great Smokies has been based on standing management practices. There is limited information on patterns of back country use, a survey on visitor attitudes about bears, some work on bear perceptions, a thesis on hiker use, and work under way on visitor use patterns under contract to the University of Pennsylvania. The Master Plan for the park includes information on these problems.

There has been considerable work on bears and bear problems exclusive of those identified and a substantial body of literature has been developed on bear ecology. Little has been done with the poaching problems in the park, and the impact is not known at present. Hiker impact has not been systematically quantified.

A coherent plan for research on such a diverse set of problems must be outlined to coordinate the efforts to be applied.

RESEARCH PROBLEMS CONCERNING HUMAN INTERFERENCE AND IMPACT.

A. Hiker impact - patterns of damage. The degree of damage is related to many physical variables but these relationships have not been well defined.

B. Stream quality at the high elevations. This problem concerns possible contamination of water supplies by humans and wildlife.

1. Limitations on these studies.

   a. An inventory defining these problems is required prior to conducting formal studies.

   b. These projects require National Park Service staff support which is presently not available.

2. Scientific aspects.

   a. Sample collection and analysis may of necessity be accomplished by separate groups.

   b. The data must represent a wide variety of situations.

3. Funding recommendations.

   Sample collection may require volunteer help.

C. The impact of poaching of wildlife in the park. The Park Service
    needs to know how many animals and which species are being
    removed.

    1. Scientific aspects.

        a. The study should quantify the number of animals removed
            annually, and discuss diurnal, seasonal, and annual
            variation in poaching activity.

        b. The study should examine interactions among the National
            Park Service personnel, the poachers, and other local
            people to determine how their activities influence
            poaching patterns.

        c. The social and economic basis for poaching needs
            investigation.

        d. The study should relate poaching activity to the regular
            hunting season, the activities of state fish and game
            commissions and other groups involved in stocking,
            enforcement, etc.

        e. The study should provide a plan for controlling poaching
            as a part of the probable wildlife management programs
            for the park.

    2. Recommendations for funding.

        a. Implementation of this study will depend on finding a
            willing researcher or organization. Park staff should
            not be actively involved in these projects.

        b. It is unlikely that sufficient funding for the collection
            of all necessary data through one study will be
            available.

D. The impact of illegal and indiscriminate collection on plant
    populations in the park.

    1. Limitations on the study.

        a. It may be difficult to obtain accurate information.

        b. There are legal requirements which need to proceed
            some aspects of these studies.

2. Scientific aspects.

   a. The Park Service needs to know the source of the problem - how much is organized commercial theft, how much is knowledgeable amateurs, and how much is due to ignorance on the part of the general public.

   b. The Park Service needs to know if any species are threatened by poaching and if any species have lost a substantial part of its population due to these thefts.

   c. The Park Service needs to know the patterns of plant removal and possible methods for combating this problem.

3. Funding recommendations.

   a. Not a project for National Park Service staff.

   b. This would make a good project for a non-NPS supported study. Part of the work needs to be done in the spring; however, some illegal collection activities may correlate to blooming or fruiting times.

E. The control or inhibition of roadside and trailside bears. (Beggar bears, mugger bears, and garbage bears.) This problem has already received some attention from the University of Tennessee Wildlife Unit, and they may continue work in this area.

   1. Limitations on the study.

   The University of Tennessee group, under Dr. Michael Pelton, have examined a number of problems on bears.

   2. Scientific aspects of the study.

   The study should emphasize new, unique, and unusual ways of discouraging bears along roads and trails. The primary goal of the work should be the development of a management plan to maintain a bear population that is as "wild" as possible.

   3. Funding recommendations.

   Funding of these projects will be on an availability basis.

F. The impact of park visitors on water quality and aquatic systems.
    This is a very diverse problem, and might be best approached
    with several studies. Areas which need investigation include
    fishing, tubing, swimming, and siltation from camping and other
    activities.

    1. Scientific aspects.

        a. The U.S. Fish and Wildlife already has creel census data.

        b. Siltation and disturbance of aquatic life:

            (1) When a fisherman wades in a stream or climbs down
                 a bank, what is the impact?

            (2) When recreationists float down a river, does the
                 stream bed sustain any notable damage?

            (3) Does intense use by swimmers and boaters cause
                 soil or bank erosion?

            (4) Many of the campsites in the park are on stream
                 banks. What is their impact? Is there an optimal
                 place to put a campsite so that water is available
                 but contamination and siltation are avoided?

            (5) Does visitor use have any adverse impact on the
                 aquatic biota?

            (6) Where are the streams most disturbed by visitor
                 use? Should the Park Service attempt to modify
                 visitor use to either disperse or concentrate the
                 damage?

    2. Funding aspects.

        This item should be conducted concurrently with the wild
        boar study, or be deferred until the effect of wild boar
        on levels of stream siltation has been completed.

IV. Fire Control

A. The problem.

With the inclusion of much of the park in wilderness, it may be desirable to let "natural" fires burn rather than attempting to control them immediately. Before the foundation of the park there were several large fires in the Smokies (most of these fires probably followed logging activity) and the local residents set numerous small fires, particularly in the xeric oak and pine forests. Natural fires caused by lightening were rarely controlled. Under Park Service management, all fires have been strictly and immediately suppressed.

B. The status of present management.

The park spends a considerable amount of money on fire control equipment and fire control crews. All fires reported are suppressed as soon as possible. The park, however, has relatively few fires and almost none of the fires in recent years have spread over large areas. Recovery by vegetation and wildlife is usually very rapid. Damage by fire could not be considered a management problem in this park at the present time.

C. The status of present research.

One thesis has been prepared on the pattern of fires in the park and the surrounding National Forests (Barden 1974) and several related papers were presented at Tall Timbers Fire Ecology Conference in 1973. Both Park Service and the Forest Service keep detailed records on fires on the region and TVA maintains weather stations and collects climatic data on a daily basis. Research in this area is being conducted in other parks and the results may lead to improvements in the process of making decisions concerning fire control. The literature on fires and their behavior is massive, but no known review of the literature pertinent to the situation in the Smokies has been undertaken.

D. Future research needs.

Fire management is very closely related to basic resource inventory. After a manager finds out where a fire is, he needs to know what sort of plant communities are involved, the past fire history of the area, type and quantity of fuel available, the weather conditions, the probable cause of the fire, and the positions of any nearby areas or objects which

should not be burned (i.e., Ranger stations, campgrounds, special protection areas, developments outside of the park boundary).

Without adequate vegetation maps for the park, a previous fire history, information on fuel types and a fire management plan, a manager cannot make a decision about fire control without visiting and completely inspecting the site of the fire. If all fires are suppressed, then almost no information on the fire is needed, but if some fires are to be permitted to burn, then adequate information will be required for sound decision making.

A decision making system (based on an interactive computer program) is being developed for Glacier National Park. Something of this sort could probably be easily instituted (possibly even without the computer) in Great Smoky Mountains National Park if the basic resource inventory and fire history data became available.

A change in management policy in this area rests, therefore, on an improvement in Basic Resource Inventory, (see Basic Resource Inventory section), and on an extension of Barden's work in terms of fuel and forest types present in the park. Eventually the information will have to be integrated into a preliminary fire management plan which could then be tested in some segment of the park.

V. Pine Bark Beetle damage - where and when.

    A. The problem.

       The southern pine bark beetle is attacking pine stands in the park. The Park Service, at present, has no plans to control the beetle, but is interested in the impact and role of this species on the native plant communities.

    B. The status of the management effort.

       Beetle-killed trees were felled in the early 1950's, but this is no longer practiced in the park. The beetle is presently accepted as a natural part of the park ecosystem.

    C. The status of the present research effort.

       The U.S. Forest Service now has a major research program on southern pine bark beetle. No research is presently being done in the park.

    D. Research needs.

       Work is needed defining the progress of plant succession following beetle kills. The presence of dead pine stands is a very important fuel factor and should be related to fire control. This work needs to be integrated into the park's basic resources inventory.

    E. Funding recommendations.

       1. Not recommended for funding in 1975 unless a small proposal involving only field support is submitted.

       2. Priority of park beetle studies is related to the determination and the adequacy of existing other agency information.

I. The maintenance of Grassy Balds.

    A. The problem.

        Some of the park's most scenic high elevation plant communities
        are slowly changing because of the natural process of plant
        succession.

    B. The status of the present management effort.

        Management techniques are presently being tested.

    C. The status of the research effort.

        A study is presently contracted to Mary Lindsay from Cornell
        University. Plans are to finish the preliminary vegetation
        work in January, 1976.

    D. After this preliminary report (including mapping of the areas)
        is finished, the study will continue for several years. It
        will include checking the existing test plots and establishing
        new ones. The study should continue under direction of Park
        Service personnel.

    E. Future status.

        Currently, research on this problem is adequate and progressing
        satisfactorily. The park scientific staff is planning to take
        over this work in the summer of 1976. At that time a
        determination will be made as to whether the work can continue
        without outside contractors - if not, the problem and its
        priority should be reconsidered in 1976-1977.

II. Exotic plant species - population expansion.

    A. The problem.

        The park's vascular flora contains a number of non-native
        species, some of which could potentially displace native
        species or modify natural successional sequences.

B. The status of the present management effort.

Kudzu is being controlled and has not become widely established
in the park. An active control program does not exist for other
exotic plant species.

C. The status of the research effort.

A field survey was conducted under NPS direction in the summer
of 1975 to determine the status of five woody exotics within
the park. A management report is being prepared. This work
will be repeated sometime in the future (probably about 1980)
to determine if any further invasion has occurred. Unless
there is a sudden population expansion of some exotic species
in the next few years, little further work on distribution is
needed, other than locating mature individuals of some of the
species which should be removed.

D. Future status.

The distribution work should be repeated in the future, but
probably not in 1975-76 or 1976-77.

Other work should continue in conjunction with management programs
and Resources Basic Inventory.

III. Acid pollution of streams.

A. The problem.

A few small streams in the park were found to be without a
viable trout population. The cause was determined to be
acid leachate contamination eminating from rocks of the
Anakeesta Formation. This problem is particularly apparent
where Anakeesta materials have been used as road fill.

B. Status of the present management effort.

Although no reconditioning program is being proposed for
the problem areas, the Park Service is now considering geology
and geochemistry in the planning process for roads and other
developments being considered within park boundaries.

C. The status of the research effort.

    The biological effects of leachate from Anakeesta materials
    are being studied by Dr. Eric Morgan at Tennessee Technological
    University in conjunction with work by NPS personnel. Detailed
    chemical analyses are being acquired by Dr. J. Roger Bacon of
    Western Carolina University. Although the chemical and biological
    nature of the processes involved need further definition, the
    source and scope of the problem has been defined and documented
    and low level follow up work by NPS staff is underway.

D. Research needs.

    One of the more fortunate effects of the Anakeesta problem has
    been an increased awareness of aquatic problems in the park.
    Acid stream contamination has not been found to be wide ranging.
    The Anakeesta Formation outcrops extensively in the central portions
    of the park and an understanding of the interaction of this unit
    with hydrologic and biologic systems is being evaluated.

E. Future status.

    The current basic work on acid leachate will be concluded in
    1976. Work on aquatic systems receiving acid leachate will
    continue at low levels as part of the basic research program
    for the park.